

management of freshwater habitat during a period of changing ocean survival could easily give misleading results if the experiment were monitored only in terms of numbers of adults. Field experiments with small spatial scales can give similarly misleading results (Peterman 1991; Walters 1997).

Replication is also a problem. There is only one Stanislaus River, so it is not possible to replicate experimental management of the Stanislaus. Experimental management of the Toulumne and the Merced rivers could be useful approximations to such replication, but would not be the real thing, and although it might be the best that can be done, the meaning of the results of such experimental management will be to some degree compromised. Measurement uncertainty adds to the difficulties.

There is no easy solution to these problems, so it is not reasonable to expect adaptive management experiments to produce unambiguous results within a few years. On the positive side, analytical and statistical methods have been developed or applied in ecology (e.g., Hilborn and Mangel 1997) that could be applied as well to adaptive management. However, these methods, such as Bayesian statistics, are unfamiliar to most scientists working on Bay/Delta issues.

### Political Difficulties with Adaptive Management

Resource management is complicated by social as well as scientific uncertainty (Halbert 1993), and even in the context of fisheries, adaptive management can fail through unanticipated social responses to management experiments. As noted by Volkman and McCannaha (1993), applying adaptive management to ecosystems promises "a mare's nest of controversies:"

The notion that we are willing to take dramatic steps in order to learn — to create control cases, and then to depart sharply from them — can, in a high-stakes setting like the Columbia River, be exceedingly problematic. It is difficult to convince people of the wisdom of investing public funds, or risking harm to a species on the brink of extinction, while embracing the scientific method's root principle that failure is not only possible, but likely, and may be necessary in order to learn.

The notion that we place a high value on learning ignores the fact that in some instances, ignorance has value. As long as key questions are open, parties remain free to take political positions. In the long term, the truth may set us free, but in the short term, it can reduce our room to maneuver. "Good science" becomes that which supports one's position.

The supposition that we are willing to wait patiently for answers that may take decades to determine, runs against the grain of

politics. If salmon are declining, the political impulse is to change course, regardless of whether we understand the problem.

Good science can run into equity considerations. Is it fair to ask Indian tribes, whose harvest has been in sharp decline for decades, to go slow on hatchery technology that has fueled non-Indian harvest for decades because we need to explore the long-term effects on salmon populations.

All of these factors point to a simple, but very hard lesson: adaptive management does not take these decisions out of the political arena. Decision makers still have to gain political support to test important hypotheses. All of the aversion to risk and expense, the impatience with slow answers, the uses of ignorance, the bureaucratic inertia from all quarters, and the fear of failure still come into play. Adaptive management does not allow us to escape unscientific pressures.

### Conclusions

Adaptive management as described here is a bitter pill, and despite its therapeutic benefits is accordingly difficult to implement. On the one hand, scientists must acknowledge that in some sense they do not know what is going on, and managers must acknowledge that in a similar sense they do not know what they are doing; on the other hand, those subject to management actions must acknowledge that uncertainty does not justify inaction. All must accept that progress will be slow, and that substantial sums must be allocated to monitoring and evaluation, probably at the expense of additional restoration efforts. Only the alternatives are less palatable.

### Acknowledgements

These notes were prepared with financial support from the Ag-Urban Ecosystem Team.

### Literature Cited

- Castleberry, D.T. and 11 others. 1996. Uncertainty and Instream flow standards. *Fisheries*, 21(8):20-21.
- Halbert, C.L. 1993. How adaptive is adaptive management? Implementing adaptive management in Washington State and British Columbia. *Reviews in Fisheries Science* 1:261-283.
- Healey, M.C. 1997. Paradigms, policies and prognostication about watershed ecosystems and their management. To appear in: R.J. Naiman and R.E. Bilby (ed.) *Ecology and Management of Streams and Rivers in the Pacific Northwest Coastal Ecoregion*. Springer-Verlag, New York.
- Healey, M.C. and T.M. Hennessey. 1994. The utilization of scientific information in the management of estuarine ecosystems. *Ocean and Coastal Management* 23:167-191.
- Hennessey, T.M. 1994. Governance and adaptive management of estuarine ecosystems: the case of Chesapeake Bay. *Coastal Management* 22:119-145.
- Hilborn, R. and M. Mangel. 1997. *The Ecological Detective: confronting models with data*. Princeton University Press.

- Hodge, R. 1990. Statement of Decision, Environmental Defense Fund v. East Bay Municipal Utility District, Alameda County (California) Action Number 425955.
- Holling, C.S. (ed.) 1978. *Adaptive Environmental Assessment and Management*. John Wiley & Sons.
- Kondolf, G.M., J.C. Vick, and T.M. Ramirez. 1996. Salmon spawning habitat rehabilitation on the Merced River, California: and evaluation of project planning and performance. *Transactions of the American Fisheries Society* 125:899-913.
- Lee, K. and Lawrence, J. 1986. Restoration under the Northwest Power Act. *Environmental Law* 16:423-459.
- Ludwig, D., R. Hilborn, and C. Walters. 1993. Uncertainty, resource exploitation, and conservation; lessons from history. *Science* 260:17&36.
- Ludwig, D. and C.J. Walters. 1985. Are age-structured models appropriate for catch and effort data? *Canadian Journal of Fisheries and Aquatic Science* 42:1066-1072.
- McAllister, M.K. and R.M. Peterman. 1992. Experimental design in the management of fisheries: a review. *North American Journal of Fisheries Management* 12:1-18.
- Mangel, M. and 41 others. 1996. Principles for the conservation of wild living resources. *Ecological Applications* 6:338:362.
- O'Neil, R.V., D.L. DeAngelis, J.B. Waide, and T.F.H. Allen. 1986. *A Hierarchical Concept of Ecosystems*. Princeton University Press.
- Pearcy, W.G. 1997. Salmon production in changing ocean domains. Pages 331-352 in D.J. Strouder, P.A. Bisson, and R.J. Naiman, eds., *Pacific Salmon and Their Ecosystems*. Chapman and Hall, New York.
- Peterman, R.M. 1991. Density-dependent marine processes in North Pacific salmonids: lessons for experimental design of large-scale manipulations of fish stocks. Pages 69-77 in S. Lockwood, ed. *The*

*ecology and management aspects of extensive aquaculture*. International Council for the Exploration of the Sea, Marine Science Symposium 192, Copenhagen.

- Power, M.E., W.E. Deitrich, and K.O. Sullivan. In press. Experimentation, observation, and inference in river and watershed investigations. To appear in W.J. Reserits and J. Bernardo, eds., *Issues and perspectives in experimental ecology*. Oxford University Press.
- Ricker, W.E. 1954. Stock and Recruitment. *Journal of the Fisheries Research Board of Canada* 11:559-623.
- Shrader-Frechette, K.S., and E.D. McCoy. 1992. Statistics, costs and rationality in ecological inference. *Trends in Ecology and Evolution* 7:96-99.
- Slocumbe, D.S. 1993. Implementing ecosystem-based management. *BioScience* 43:612-622.
- Volkman, J.M. and W.E. McCannaha. 1993. Through a glass darkly: Columbia River salmon, the Endangered Species Act, and adaptive management. *Environmental Law* 23:1249-1272.
- Walters, C.J. 1986. *Adaptive Management of Renewable Resources*. McGraw-Hill, New York.
- Walters, C.J. 1997. Challenges in Adaptive Management of Riparian and Coastal Ecosystems. *Conservation Ecology* [online] 1(2):1. Only available via the Internet. URL: <http://www.consecol.org/vol1/iss2/art1>.
- Walters, C.J. and R. Hilborn. 1976. Adaptive control of fishing systems. *Journal of the Fisheries Research Board of Canada* 33:145-159.
- Walters, C.J. and C.S. Holling. 1990. Large-scale management experiments and learning by doing. *Ecology* 71:2060-2068.
- Wood, C.A. 1994. Ecosystem management: achieving the new land ethic. *Renewable Resources Journal* 12(Spring):6-12.

### Third Delta Smelt Workshop is Set for October

The Third Delta Smelt Workshop is scheduled for October 1-2, 1998. A location will be chosen based on the number of responses to this announcement and an earlier e-mail solicitation of interest. The workshop will provide updates on the progress in understanding delta smelt biology since early 1996, when the last workshop was held.

The first day of the workshop will consist of presentations of new and ongoing work regarding delta smelt biology. A panel discussion will occur toward the end of the day. The second day will consist of a one-half day meeting of technical experts to discuss the nuts and bolts of delta smelt monitoring and research. The first day is open to all interested individuals. The second day is limited to technical experts with direct involvement in planning or implementing delta smelt projects.

Products expected from the workshop include an IEP newsletter article, and an IEP technical report including abstracts of the presentations, a complete delta smelt bibliography, a summary of the meeting by one or more of the Science Advisory Group, and a summary of issues discussed at the second day of the meeting.

If you are interested in attending and DID NOT respond to the earlier e-mail solicitation of interest, please send a note, preferable via e-mail, to Larry Brown, U.S. Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA, 95825, Phone: 916-978-5043, FAX: 916-978-5055, e-mail: [lbrown@mp.usbr.gov](mailto:lbrown@mp.usbr.gov). A final